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MODEL ANALYSIS AND EXPERT SYSTEM DEVELOPMENT FOR PLANNING AND SCHEDULING TELEOPERATIONS FOR AIRCRAFT TURNAROUND FUNCTIONS

VOLUME 2 - TOP USER'S GUIDE

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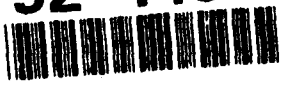

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This report summarizes the results of a 3-year effort to study the planning and scheduling of aircraft turnaround functions using an expert system to minimize the turnaround time. This effort established the feasibilityof using expert system technology to model aircraft turnaround functions in a teleoperated environment. The model "opportunistically" generates schedules based on aircraft turnaround functions (refueling, weapons loading, aircraft inspection, maintenance, etc.) and personnel assignments and automation technologies. The model is conceptualized for a dynamic environment. Thus, it is possible for the model to consult its knowledge base in order to identify scheduling strategies to maximize aircraft turnaround efficiency for a particular function.

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1. INTRODUCTION

This part of the report presents information on the TOP expert system for aircraft turnaround function (ATF). TOP is an acronym for a Task Oriented Planner. TOP environment utilizes the principle of Open Programming System (OPS) architecture. An OPS concept is an extension of a blackboard problem solving architecture [1] to include dynamic context focusing. In TOP, the planner is developed under the ARTFUL™ library, the scheduler is developed using a NEXPERT™ expert system shell, and the interface between the planner and scheduler is under a compiled dBASE III™ Plus environment. In the TOP domain, knowledge about the world of aircraft turnaround configuration is prepared by the planner. The plan for a particular ATF is passed to the scheduler who prepares a detailed task assignment and time-window schedule. Similar to the blackboard architecture, information migrates between the planner and the scheduler as intracellular units based on the levels of abstractions set up by the planner.

1.1 ATF Planner

The discussions that follow are for F-16A aircraft selected for this contract (see Appendix A). Most ATF tasks consist of refuelling, rearming and minor aircraft maintenance during combat missions or training exercises. When an aircraft is returning after delivering a sortie, the pilot relays the status of the aircraft to the ground crew in order to give them a head start on preparations for turnaround. The crew chief gives thorough visual

examination of the aircraft based on the pilot's information. If the aircraft has no damage, it is taxied to the turnaround area where the turnaround functions are executed.

The pilot can generate a plan based on his particular needs (context). Usually, these plans will consist of three functions of aircraft turnaround: refueling the aircraft, reloading ammunition, and reloading bombs and missiles.

At the planning phase, the ATF tasks are represented in the form of a data base (See Table 1). The planner uses the information on a plan configuration code to generate a plan. For example, the configuration code AG2 may consist of the following requests:

a) Load AIM-9L missile on stations 1 and 2.
b) Load 3MK82's on stations 2 and 7.
c) Refuel tanks located on stations 4 and 6.
d) Install ECM pods at station 5.
e) Any possible configurations of (a)-(d).

The individual stations of the aircraft are shown in Fig. 1.

Table 1: A list of possible configurations

Config Code*	9	8	7	6	5	4	3	2	1
AA1	M	M	M	-	ECM	-	M	M	M
AA2	M	M	M	370	300	370	M	M	M
AA3	M	M	M	-	-	-	M	M	M
AG1	M	-	A	A	300	A	A	-	M
AG2	M	-	A	370	ECM	370	A	-	M
AG3	-	-	B	B	ECM	B	B	-	-
AG4	M	-	C	-	300	A	A	-	M
AG5	M	-	C	370	300	370	C	-	M
AG6	M	M	B	B	300	A	A	M	M

A - 3 MK82'S MOUNTED ON A TER
B - MK84
C - 2 AGM-65'S MOUNTED ON A LAU-88 LAUNCHER
M - AIM-9L MISSILE MOUNTED ON MISSILE LAUNCHER
370 - FUEL TANK MOUNTED ON STATIONS 4 & 6
300 - FUEL TANK MOUNTED ON STATION 5

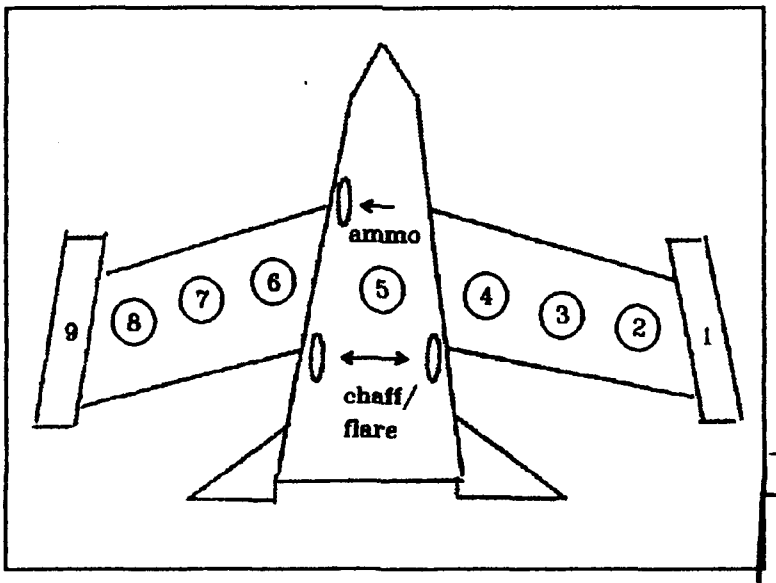

Fig 1: Stations of F-16 Aircraft

1.2 ATF Scheduler

Upon the completion of an ATF plan, the TOP scheduler picks the job with the highest priority for scheduling. The scheduling is a time-phase explosion of an ATF plan under resource constraints. Within the TOP scheduler are three parts:

a) The dBASE III™ Plus for job resource assignment which interfaces with the planner to determine resources needed before job scheduling can take place.

b) The NEXPERT™ expert system shell which uses an object programming concept to schedule jobs and explode tasks along a continuum of nondecreasing time line.

c) The dBASE III™ Plus feasible and complete job profiles. These data files contain (report) listings which include the job title and the personnel used to execute the jobs.

The TOP scheduler starts by reading the dBASE plan file as initial NEXPERT facts. The knowledge processing is triggered accordingly with the availability of these known facts. The expert system dynamically creates nodes for each job execution, the NEXPERT scheduler writes the results to two new dBASE files.

2. PROGRAM DESCRIPTIONS

The programs in TOP are independently created to enhance transportability and transparency in knowledge migration. Each program corresponds to the planner and scheduler described above. The planner control program is shown in Appendix B.

2.1 Planner Documentation

The TOP planner is under the ARTFUL™ environment called TUR.EXE. The program called tur.exe in c:\dbase subdirectory must be run while the current directory is c:\dbase. This subdirectory contains the data files necessary for the program to run. Below is a listing of the files necessary:

Directory of C:\DBASE

TURN_DICT	DBF	Data Dictionary file
FUNCTASK	DBF	Task breakdown file
JOBLIST	DBF	ATF function description file
CONFIG	DBF	ATF Configuration file

The following files are required but are only for support of the above files:

TUR_HEL1	NTX
TUR_PRIN1	NTX
TUR_RPT1	NTX
TUR_SYS1	NTX
TUR_QRY1	NTX
TUR_PRN	DBF
TUR_DIC1	NTX
TUR_HELP	DBF
TUR_RPT	DBF
TUR_QRY	DBF
TUR_QRY	DBT
FUNCTIO1	NTX
CONFIG1	NTX
FUNCTAS1	NTX
MENUS	DBF
TUR_HELP	DBT

To run the program do the following:
change to drive C:
change to directory\dbase
type TUR at the dos prompt C:\dbase>

The program is self-explanatory from this stage. It will allow you to add, edit, delete, browse the fields of the configuration for different turnaround functions and look at the relationships between the files used to store the information. If you want to/need to change any of the times, or add or delete tasks, choose the Calculate option on the main menu to update the entire system to the changes you have made. The following are the options descriptions and how to use them.

2.1.1 Main Menu Options

Aircraft

This option allows you to keep track of various aircraft-specific information. When chosen it presents you with a menu of options and a screen of aircraft specific information that the options will operate on. All options are the same for the various screens that appear from the main menu and will be discussed in more detail under the Submenu Options section of this document.

Config

This option allows you to keep track of and create configurations for planning. When chosen it presents you with the standard submenu options and a screen of configuration specific data.

T. A. F

This option allows you to keep track of turnaround aircraft

functions. When chose.. it presents you with the standard submenu options and a screen of functions specific data. This option is the driver for the scheduler.

Functions Tasks

This option allows you to keep track of specific function tasks. When chosen it presents you with the standard submenu options and a screen of tasks specific data. This option is used to calculate the total time for each specific function task.

Calculate

This function updates the system after changes have been made to the fields of any of the databases. It must be used before running the scheduler if any changes have been made to the system. It exports data to the scheduler database.

Utilities

This menu allows the user the ability to add new databases to the system, pack all existing databases, maintain the help and query system, change the system color configurations, and view a text file.

2.1.2 Submenu Options

Add

This option allows you to add new records to the current database. The current database name is displayed in the lower left hand corner. This main menu option that you choose to get to the submenu should indicate the database to which you will be adding.

Browse

This option will allow you to view without being able to change a record in the current database. This screen allows you to view a complete record on one line of the screen. Use the cntl-cursor keys to pan over if all the fields are not visible on the screen.

Calc

This option allows you to sum all of the numeric fields in the current database. It can be used to get a total of some field to check or verify data entry.

Dup

This option is for duplicating the existing record when doing data entry. It will save a lot of key strokes if most of the data being entered has repeating fields.

Edit

This option allows for the changing of any of the fields in the currently displayed record. Press ctrl-W to save or press enter on the last field in the record to save the changes made to the record.

Find

This option allows you to search the database for a specific record based on the current index key. It will prompt you for the correct data and format before beginning the search.

List

This option will list and run any predefined reports that are in the system. The reports need to be defined in the R&R format and are not currently supported in this release of the software, but is included for future upgrade capability.

Query

This option will let the user generate a query based on any of the fields of the current database and display on the records that make the query true. This can be used to do "what if" analysis on a specific database if desired.

2.2 Planner Data Structures

The following data structures fully describe the task allocation functions storage utilization and field requirements.

2.2.1 Structure for Database: JOBLIST.DBF

Field	Field Name	Type	Width	Dec
1	ID	Numeric	10	
2	FUNCCODE	Character	3	
3	CONFIGDES	Numeric	25	
4	TIME2	Numeric	12	2
5	TIME1	Numeric	12	2
6	JOB_NAME	Character	30	
7	STATION	Numeric	10	
8	UNASSIGNED	Numeric	1	
9	STARTTIME	Numeric	12	2
10	ENDTIME	Numeric	12	2
11	TIMEPD	Numeric	12	2
12	PERSONNELL1	Character	30	
13	PERSONNELL2	Character	30	
14	PERSONNELL3	Character	30	
15	WORKING_ON	Logical	1	
16	SEQ	Numeric	2	
17	SUBTASK	Character	30	
** Total **			263	

2.2.2 Structure for Database: MENUS.DBF

Field	Field Name	Type	Width	Dec
1	MENU_NO	Numeric	2	
2	NO_OPTIONS	Numeric	2	
3	COL_NO	Numeric	2	
4	MENU_WIDTH	Numeric	2	
5	CUE_1	Character	40	
6	CUE_2	Character	40	

7	CUE_3	Character	40
8	CUE_4	Character	40
9	CUE_5	Character	40
10	CUE_6	Character	40
11	CUE_7	Character	40
12	CUE_8	Character	40
13	CUE_9	Character	40
14	CUE_10	Character	40
15	CUE_11	Character	40
16	CUE_12	Character	40
17	CUE_13	Character	40
18	CUE_14	Character	40
19	CUE_15	Character	40
20	UDF_1	Character	60
21	UDF_2	Character	60
22	UDF_3	Character	60
23	UDF_4	Character	60
24	UDF_5	Character	60
25	UDF_6	Character	60
26	UDF_7	Character	60
27	UDF_8	Character	60
28	UDF_9	Character	60
29	UDF_10	Character	60
30	UDF_11	Character	60
31	UDF_12	Character	60
32	UDF_13	Character	60
33	UDF_14	Character	60
34	UDF_15	Character	60
** Total **			1509

2.2.3 Structure for Database: FUNCTASK.DBF

Field	Field Name	Type	Width	Dec
1	FUNCCODE	Character	3	
2	TASK	Character	30	
3	TJ	Numeric	3	
4	SJ	Numeric	1	2
5	DJ	Numeric	4	
6	FJ	Numeric	2	
7	HAZ_TIME	Numeric	7	2
8	NHAZ_TIME	Numeric	7	2
9	RESOURCE1	Character	1	
10	RESOURCE2	Character	1	
11	RESOURCE3	Character	1	
** Total **			61	

2.2.4 Structure for Database: TUR DICT.DBF

Field	Field Name	Type	Width	Dec
1	ALIAS	Character	10	
2	FILE_NAME	Character	12	
3	DESCRIPT	Character	30	
4	OPEN_IT	Logical	1	
5	EXCLUSIVE	Logical	1	
6	ID_CHAR	Character	3	
7	NO_KEYS	Numeric	1	
8	NO_KIDS	Numeric	1	
9	DEL-STATUS	Numeric	1	
10	DELETIONS	Logical	1	
11	UDF_DEL	Character	20	
12	HELP_CODE	Character	10	
13	NO_SCREENS	Numeric	2	
14	TOP_ROW	Numeric	2	
15	SCREEN_LEN	Numeric	2	
16	BTR	Numeric	2	
17	BTC	Numeric	2	
18	BBR	Numeric	2	
19	BBC	Numeric	2	
20	MTR	Numeric	2	
21	MTC	Numeric	2	
22	MBR	Numeric	2	
23	MBC	Numeric	2	
24	MENU_MESGS	Logical	1	
25	UDF_ADD	Character	20	
26	BROWSER	Character	20	
27	UDF_BROW	Character	20	
28	BROW_EXC	Character	20	
29	BROWS_FLDS	Numeric	2	
30	UDF_CALC	Character	20	
31	UDF_COPY	Character	20	
32	UDF_EDIT	Character	20	
33	UDF_INIT	Character	20	
34	UDF_LIST	Character	20	
35	UDF_MEMO	Character	20	
36	UDF_QUERY	Character	20	
37	UDF_RPL	Character	20	
38	UDF_SEARCH	Character	20	
39	UDF_ZOOM	Character	20	
40	CUE_1	Character	40	
41	KEY_1	Character	80	
42	PIC_1	Character	30	
43	KTYPE_1	Character	1	
44	UNIQUE_1	Logical	1	
45	CUE_2	Character	40	
46	KEY_2	Character	80	
47	PIC_2	Character	30	
48	KTYPE_2	Character	1	
49	UNIQUE_2	Logical	1	

50	CUE_3	Character	40
51	KEY_3	Character	80
52	PIC_3	Character	30
53	KTYPE_3	Character	1
54	UNIQUE_3	Logical	1
55	CUE_4	Character	40
56	KEY_4	Character	80
57	PIC_4	Character	30
58	KTYPE_4	Character	1
59	UNIQUE_4	Logical	1
60	CUE_5	Character	40
61	KEY_5	Character	80
62	PIC_5	Character	30
63	KTYPE_5	Character	1
64	UNIQUE_5	Logical	1
65	CUE_6	Character	40
66	KEY_6	Character	80
67	PIC_6	Character	30
68	KTYPE_6	Character	1
69	UNIQUE_6	Logical	1
70	CUE_7	Character	40
71	KEY_7	Character	80
72	PIC_7	Character	30
73	KTYPE_7	Character	1
74	UNIQUE_7	Logical	1
75	KID_1	Character	10
76	KCUE_1	Character	20
77	KREL_1	Character	30
78	KID_2	Character	10
79	KCUE_2	Character	20
80	KREL_2	Character	30
81	KID_3	Character	10
82	KCUE_3	Character	20
83	KREL_3	Character	30
84	KID_4	Character	10
85	KCUE_4	Character	20
86	KREL_4	Character	30
87	KIDS_5	Character	10
88	KCUE_5	Character	20
89	KREL_5	Character	30
90	NO_RELS	Numeric	2
91	HOME_1	Character	10
92	RLKEY_1	Character	40
93	LUKUP_1	Character	10
94	RLTYPE_1	Character	1
95	HOME_2	Character	10
96	RLKEY_2	Character	40
97	LUKUP_2	Character	10
98	RLTYPE_2	Character	1
99	HOME_3	Character	10
100	RLKEY_3	Character	40
101	LUKUP_3	Character	10

102	RLTYPE_3	Character	1
103	HOME_4	Character	10
104	RLKEY_4	Character	40
105	LUKUP_4	Character	10
106	RLTYPE_4	Character	1
107	HOMES_5	Character	10
108	RLKEY_5	Character	40
109	LUKUP_5	Character	10
110	RLTYPE_5	Character	1
111	HOME_6	Character	10
112	RLKEY_6	Character	40
113	LUKUP_6	Character	10
114	RLTYPE_6	Character	1
115	HOME_7	Character	10
116	RLKEY_7	Character	40
117	LUKUP_7	Character	10
118	RLTYPE_7	Character	1
119	HOME_8	Character	10
120	RLKEY_8	Character	40
121	LUKUP_8	Character	10
122	RLTYPE_8	Character	1
** Total **			2251

2.2.5 Structure for Database: TUR PRN.DBF

Field	Field Name	Type	Width	Dec
1	TYPE_STYLE	Character	20	
2	CHR_1	Numeric	3	
3	CHR_2	Numeric	3	
4	CHR_3	Numeric	3	
5	CHR_4	Numeric	3	
6	CHR_5	Numeric	3	
7	CHR_6	Numeric	3	
** Total **			39	

2.2.6 Structure for Database: TUR SYS.DBF

Field	Field Name	Type	Width	Dec
1	USERNAME	Character	40	
2	USERNUM	Character	4	
3	PASSWORD	Character	8	
4	PERMISSION	Character	10	
5	USERPATH	Character	40	
6	SCR_PATH	Character	20	
7	CLOSE_OK	Logical	1	
8	EDIT_HELP	Logical	1	
9	CURRENCY	Character	3	
10	TAX_CONDIT	Character	60	
11	TAX_RATE	Numeric	5	
12	COMPANY	Character	50	

13	ADDRESS	Character	50
14	CITY	Character	50
15	PHONE	Character	50
16	COLOR_1	Character	20
17	COLOR_2	Character	20
18	COLOR_3	Character	20
19	COLOR_4	Character	20
20	COLOR_5	Character	20
21	COLOR_6	Character	20
22	COLOR_7	Character	20
23	COLOR_8	Character	20
24	COLOR_9	Character	20
25	COLOR_10	Character	20
26	COLOR_11	Character	20
27	COLOR_12	Character	20
28	COLOR_13	Character	20
29	MONO_1	Character	20
30	MONO_2	Character	20
31	MONO_3	Character	20
32	MONO_4	Character	20
33	MONO_5	Character	20
34	MONO_6	Character	20
35	MONO_7	Character	20
36	MONO_8	Character	20
37	MONO_9	Character	20
38	MONO_10	Character	20
39	MONO_11	Character	20
40	MONO_12	Character	20
41	MONO_13	Character	20
** Total **			913

2.2.7 Structure for Database: CONFIG.DBF

Field	Field Name	Type	Width	Dec
1	AC_ID	Character	3	
2	CONFIGCODE	Character	3	
3	STATION9	Character	3	
4	STATION8	Character	3	
5	STATION7	Character	3	
6	STATION6	Character	3	
7	STATION5	Character	3	
8	STATION4	Character	3	
9	STATION3	Character	3	
10	STATION2	Character	3	
11	STATION1	Character	3	
** Total **			34	

2.2.8 Structure for Database: FUNCTION.DBF

Field	Field Name	Type	Width	Dec
1	ID	Numeric	10	
2	FUNCCODE	Character	3	
3	CONFIGDES	Character	25	
4	TIME2	Numeric	12	2
5	TIME1	Numeric	12	2
6	JOB_NAME	Character	30	
7	STATION	Numeric	10	
8	UNASSIGNED	Numeric	1	
9	STARTTIME	Numeric	12	2
10	ENDTIME	Numeric	12	2
11	TIMEPD	Numeric	12	2
12	PERSONNELL1	Character	30	
13	PERSONNELL2	Character	30	
14	PERSONNELL3	Character	30	
15	WORKING_ON	Logical	1	
16	SEQ	Numeric	2	
17	SUBTASK	Character	30	
** Total **			263	

2.2.9 Structure for Database: TUR RPT.DBF

Field	Field Name	Type	Width	Dec
1	RI_REPORT	Character	30	
2	RI_LIBRARY	Character	20	
3	RI_MASTER	Character	20	
4	RI_ALIAS	Character	10	
5	RI_ORDER	Numeric	2	
6	RI_KEYEXP	Character	40	
7	RI_KEYCUE	Character	40	
8	RI_KEYPIC	Character	40	
9	RI_OUTFILE	Character	12	
10	RI_OUTAPPN	Logical	1	
11	RI_PEQUIT	Logical	1	
12	RI_CHKTIME	Character	1	
13	RI_NOESC	Logical	1	
14	RI_PRINTER	Character	1	
15	RI_BEGPAGE	Numeric	4	
16	RI_ENDPAGE	Numeric	4	
17	RI_TEST	Logical	1	
18	RI_SCOPE	Character	1	
19	RI_LOSCOPE	Character	1	
20	RI_HISCOPE	Character	50	
21	RI_COPIES	Numeric	4	
22	RI_FILTER	Character	250	
23	RI_QUERY	Character	1	
24	RI_DISPERR	Logical	1	
25	RPT_TYPE	Character	1	
26	RPT_INIT	Character	20	

27	RPT_MAIN	Character	20
28	RPT_EXIT	Character	20
29	RPT_FRMLBL	Character	8
30	RPT_HEAD	Character	40
31	RPT_SUMM	Logical	1
32	IS_FRONT	Logical	1
** Total **			697

2.2.10 Structure for Database: UPLDSTAT.DBF

Field	Field Name	Type	Width	Dec
1	ID	Numeric	1	
2	STATION	Logical	1	
** Total **			3	

2.2.11 Structure for Database: TUR HELP.DBF

Field	Field Name	Type	Width	Dec
1	SUBJECT	Character	35	
2	HELP	Memo	10	
3	HELP_KEY	Character	15	
4	VARIABLE	Character	15	
5	HTR	Numeric	2	
6	HTC	Numeric	2	
7	HBR	Numeric	2	
8	HBC	Numeric	2	
** Total **			84	

2.2.12 Structure for Database: TUR QRY.DBF

Field	Field Name	Type	Width	Dec
1	QUERY_NAME	Character	25	
2	DATA_FILE	Character	10	
3	USERNUM	Character	4	
4	OPEN	Logical	1	
5	QUERY	Memo	10	
** Total **			51	

2.2.13 Structure for Database: AIRCRAFT.DBF

Field	Field Name	Type	Width	Dec
1	AD_ID	Character	3	
2	AC_NAME	Character	20	
3	STATUS	Character	3	
4	SITE_NUM	Character	3	
5	MISSION_ID	Character	3	
6	CREWSIZE	Character	2	
** Total **			35	

2.2.14 Index Files

The index files are described below for all databases in the planner.

Filename	Type	Index Expression
FUNCTIO1.NTX	CLIP	FUNCCODE
CONFIG1.NTX	CLIP	CONFIGCODE
TUR_HEL1.NTX	CLIP	HELP_KEY+VARIABLE
FUNCTAS1.NTX	CLIP	FUNCCODE
AIRCRAFT1.NTX	CLIP	AC_ID
TUR_PRN1.NTX	CLIP	TYPE_STYLE
TUR_RPT1.NTX	CLIP	RI_REPORT
TUR_SYS1.NTX	CLIP	USERNUM
TUR_QRY1.NTX	CLIP	DATA_FILE+QUERY_NAME
TUR_DIC1.NTX	CLIP	ALIAS
JOBLIST1.NTX	CLIP	FUNCCODE

2.3 Scheduler Documentation

The TOP scheduler is under NEXPERT™ environment. Each ATF task is set up under an object pseudo code. Upon the completion of planning, the TOP Scheduler uses the "Get Data" value to read job files. A job file created under "JOBLIST.DBF" by the planner is the initial input data to drive the scheduling algorithm.

In NEXPERT, two main characteristics of objects can be distinguished: what they represent and how they should be used by the system. The structure of an object is as follows:

name
classes
subobjects
properties

As an example, consider a turnaround function plan P1 with all the jobs to be performed: This can be represented as:

```
(     CNAME = P1
   (@CLASS = job
        (@ PROPERTIES =
     endtime          "job end time"
     id               "job ID"
     job_name         "job name"
```

```
personnel1      "crew name:
personnel2      "crew name"
personnel3      "slot for floating Crew"
starttime       "job start time"
station         "station location"
time1           "time for human"
time2           "time for robot"
timepd          "dynamic slot"
unassigned      "logical variable to assign task"
working-on )))
```

Thus, each job category has start and end times, dynamic slots to hold a vector of unassigned jobs, crew members, a job identification and the station number to be worked on. Generally, NEXPERT knowledge representation allows for dynamic objects. Dynamic objects act as instances of variables which are those classes and objects. Examples of dynamic objects are "personnel13" and "timepd" slots for holding noninstantiated variables.

A very important aspect of the object organization is the notion of inheritance, that is to say, the way objects and classes can communicate values to each other. An object will typically be able to inherit a value of one of its properties from one of its classes or parent objects. For example, any aircraft stations 1-9 will inherit the resources required to perform an ATF. All these value passing mechanisms, which represent types of default reasoning, are customizable at the lower level of object granularity: the property of the object or the class. Objects also inherit functions, or methods.

During a job schedule, the knowledge processing environment dynamically creates a "Node" for each personnel resource and the class attributes as discussed earlier. Dynamic node creation allows for possible job preemption, resumption and assignment of

idle resources.

At the end of each schedule, the system records the generated feasible schedule into a separate external dBASE file. These data remain available for later analysis.

The scheduling process consists of heuristic algorithms. The invocation of the algorithm uses rules to execute each schedule profile. For example, to select a plan for a schedule, Rule 85 below is fired first by setting a priority (INFACT) to the highest value possible:

```
(@RULE=   R85
     @INFCAT=100;
     (@LHS=
          (Yes (GetData)))
     (@HYPO=    (GoGet)
     (@RHS=
          (Retrieve ("c:\dbase\joblist.dbf")
(@TYPE=DBF3;@FILL=ADD;@NAME="' job_ '!id!";\
@CREATE= |job|, |timecode| '@PROPS=id, job_name,\
station, unassigned,time1,time2,starttime,\
endtime;@FIELDS="id","job_name","station",\
"unassigned","time1","time2","starttime",\
"endtime";))
          (Do   (MAX(<|job|>.id))      (n))
          (Do   (n)   (ctr)
          (Do   (1)   (wpcnt))
          (Do   (1)   (chcnt))
          (Retrieve   ("c:\dbase)upldstat.dbf")
(@TYPE=DBF3; @FILL=ADD;@NAME="' station'!id!";\
@CREATE=|station|;@PROPS=free;@FIELDS="station";\))

          (Let  (wp1.free)   (TRUE))
          (Let  (wp2.free)   (TRUE))
          (Let  (wp3.free)   (TRUE))
            (Let  (<|job|>.working_one)          (FALSE))
            (Do   (0)   (timeclock))
          (Let  (ch1.free)   (TRUE))
          (Let  (ch2.free)   (TRUE)))
```

A list of unassigned tasks can be constructed using the global rule:

```
          (@RULE=   R83
               (@LHS=
                    (=   (ctr)      (0))
```

```
                    (>    (SUM(<|job|>.unassigned))        (0))
                    (Is   (<|job|>.working_on)          (FALSE))

          (@HYPO=     find_smallest_timepd1)
          (@RHS=
                (Do     (99999)    (<|job|>.timepd))))
```

The task assignments are performed asynchronously using the global rule:

```
(@RULE=    R74
     (@LHS=
          (>     (ctr)          (0))
     )
     (@HYPO=     continue_assign)
     (@RHS=
          (Reset     (continue_assign))
          (Do   ('job_'\ctr\.job_name)     (current_job.job_name))
          (Do   ('job_'\ctr\.station)      (current_job.station))
          (Do  ('job_'\ctr\.unassigned)  (current_job.unassigned))
          (Do   ('job_'\ctr\.id)      (id))
          (Do   ('ctr-1)     (ctr))))
```

Finally, the global rule to check task completion and update system status is given by:

```
(@RULE=    R79
     @INFCAT=100;
     (@LHS=
          (=     (ctr)       (0))
          (=     (SUM(<|job|>.unassigned))        (0))
     )
     (@HYPO=     done)
     (@RHS=
          (Do    (MAX(<|job|>.endtime))      (timeclock))
          (Write      ("c:\dbase\finjob.dbf")
(@TYPE=DBF3;@FILL=NEW;@PROPS=starttime,endtime,\
job_name,name,station;@FIELDS="STARTTIME",\
"ENDTIME","JOB_NAME","NAME","STATION";@ATOMS=<|personnel|>;\
))
         (Write     ("c:\dbase\jobdone.dbf")
(@TYPE=DBF3;@FILL=NEW;@PROPS=job_name,starttime,\
endtime,id,station,time1,time2,unassigned,\
personnel1,personnel2,personnel3;@FIELDS=JOB_NAME",\
"STARTTIME","ENDTIME","ID","STATION","TIME1",\
"TIME2","UNASSIGNED","PERSONNE11","PERSONNE12",\
"PERSONNE12";@ATOMS=<|job|;))))
```

2.3.1 Dynamic Job Schedule Generation

The TOP scheduler has 14 rules that control dynamic job scheduling policies. These rules are set up as "a working group." If, say, a job requires three weapon crewmen, the dynamic variable "wpg3" will be set to a true value. The inference engine will use this truth value to dynamically create a working node for each weapon crewman. With this, it is possible to keep track of each of the personnel's status (idle or busy) during a particular instance. (Exhibit-2 shows a sample of dynamic node creation). In addition, a new object node will be created whenever the job or subtask has been assigned. The newly created node, "NEWJOB," inherits the property of a job class which includes job-name, subtask, station, start-time, endtime, and personnel.

The "SEQ" field in Joblist.dbf controls the dynamic sequence of creating subtask nodes during knowledge processing. For instance, "Load Aim-9L Missile" which has three subtasks, pre-loading, loading and postloading, will have a "SEQ" value = 3. With a "SEQ" value of 3, the only "preloading" node is created initially and "SEQ" will be updated to 2. With a "SEQ" value of 2, the "loading" node is created and "SEQ" becomes 1. After the last subtask, which has the "SEQ" value of 1, postloading" has been assigned, the whole job "Load Aim-9L Missile" is complete and "job-assigned" variable will be set to true.

2.3.2 Executable File for Scheduling

To run the NEXPERT knowledge base file, do the following:

1. Under DOS, type "win/r" to get into window environment.
2. Click Nexpert Icon to get into Nexpert.
3. Double clicks at Expert on the menu, then click "Load Knowledge Base."
4. Click "AFCMP.KB."
5. Double click the "True" for the value of "GetData."
6. When it finishes, double click the top left corner and exit from Nexpert.
7. Under Dbase, turn on the printer, and type "DO PRTLIST" to get the listings.

Exhibit-2 Sample Dynamic Node Creation In

Hypothesis	Variable	Group
nodetype1	wpg3	wp1,wp2,wp3
nodetype2	wpg2a	wp1,wp2
nodetype3	wpg2b	wp1,wp3
nodetype4	wpg2c	wp2,wp3
nodetype5	wpg1a	wp1
nodetype6	wpg1b	wp2
nodetype7	wpg1c	wp3
nodetype8	wpra	wp1,rb
nodetype9	wprb	wp2,rb
nodetype10	wprc	wp3,rb
nodetype11	cha	ch1
nodetype12	chb	ch2
nodetype13	chg	ch1,ch2
nodetype14	rb	rb

Note: nodetype(i) is the node type i created for a schedule profile. The variables are binary values which allow for a hypothesis to be true or false. The "group" column consists of ATF crews. For example, in nodetype1, the weapon group consists of three personnel wp1, wp2, wp3, respectively. Thus, in nodetype1 creation, the rule: IF wpg3 = "True," then load weapon with three crewmembers. Similar rb is for robot, ch1 and ch2 for crew chief 1 and 2. Wpg2a, wpg2b, wpg2c are possible combinations of weapon groups (e.g.; a for 1 and 2, b for 1 and 3 and c for 2 and 3). These notations can be changed by the user. The executable program file is "AFCMP.KB." The input files read from the TOP planner are

"Joblist.dbf" and Upldstat.dbf," respectively. The "Upldstat" file updates statistics during a schedule generation on each of the resources used. The output files are "Jobdone.dbf and "Findjob.dbf." The jobdone file gives information on each job: the start-time, the endtime, station in which the job was performed, the subtasks completed and the personnel used. The findjob file stores information in a particular station.

2.4 Scheduler Data Structures

The following data structures are used by the TOP scheduler:

2.4.1 Structure for Database(C:upldstat.dbf) (See description in planning section.)

2.4.2 Structure for Database(C:jobdone.dbf)

Field	Field Name	Type	Width	Dec
1	NAME	Character	30	
2	JOB_NAME	Character	30	
3	STARTTIME	Numeric	12	
4	ENDTIME	Numeric	12	
5	ID	Numeric	10	
6	STATION	Numeric	10	
7	PERSONNEL1	Character	30	
8	PERSONNEL2	Character	30	
9	PERSONNEL3	Character	30	
10	SUBTASK	Character	30	
** Total **			225	

2.4.3 Structure for Database(C:findjob.dbf)

Field	Field Name	Type	Width	Dec
1	STARTTIME	Numeric	12	
2	ENDTIME	Numeric	12	
3	JOB_NAME	Character	30	
4	NAME	Character	30	
5	STATION	Numeric	10	
6	SUBTASK	Character	30	
** Total **			125	

3. SAMPLE RESULTS

By following the procedure to run the TOP scheduler, the results below give typical contents of each files (See Figure 2):

3.1 Finjob.dbf

The contents of Findjob.dbf is an output with crew utilization. A typical file content is given below:

Record#	STARTTIME	ENDTIME	JOB_NAME	Name
1	0.0	3.0	LOAD CHAFF/FLARE	ch1
2	0.0	3.0	LOAD CHAFF/FLARE	ch2
3	0.0	2.0	GUM AMMO LOAD	wp3
4	0.0	3.0	REFUELING	rb
5	0.0	5.0	LOAD AIM-9L MISSILE	wp1
6	0.0	5.0	LOAD AIM-9L MISSILE	wp2
7	3.0	8.0	SAFETY CHECK	ch1
8	3.0	8.0	SAFETY CHECK	ch2
9	5.0	10.0	LOAD AIM-9L MISSILE	wp3
10	5.0	10.0	LOAD AIM-9L MISSILE	rb
11	5.0	9.0	LOAD TER RACK & 3 MK82	wp1
12	5.0	9.0	LOAD TER RACK & 3 MK82	wp2
13	8.0	11.0	UNLOAD CENTERLINE PYLON & ECM	ch1
14	8.0	11.0	UNLOAD CENTERLINE PYLON & ECM	ch2
15	9.0	13.0	LOAD TER RACK & 3 MK82	wp1
16	9.0	13.0	LOAD TER RACK & 3 MK82	wp2
17	10.0	15.0	LOAD AIM-9L MISSILE	wp3
18	10.0	15.0	LOAD AIM-9L MISSILE	rb
19	11.0	16.0	LOAD 300 & REFUEL	ch1
20	11.0	16.0	LOAD 300 & REFUEL	ch2
21	15.0	20.0	LOAD AIM-9L MISSILE	wp2
22	15.0	20.0	LOAD AIM-9L MISSILE	wp3
23	15.0	20.0	LOAD AIM-9L MISSILE	wp1
24	15.0	20.0	LOAD AIM-9L MISSILE	rb
25	20.0	25.0	LOAD AIM-9L MISSILE	wp2
26	20.0	25.0	LOAD AIM-9L MISSILE	wp3
27	25.0	29.0	UNLOAD MISSILE LAUNCHER	wp1
28	25.0	29.0	UNLOAD MISSILE LAUNCHER	wp2
29	25.0	29.0	UNLOAD MISSILE LAUNCHER	wp3
30	29.0	33.0	UNLOAD MISSILE LAUNCHER	wp1
31	29.0	33.0	UNLOAD MISSILE LAUNCHER	wp2
32	29.0	33.0	UNLOAD MISSILE LAUNCHER	wp3
33	33.0	37.0	LOAD TER RACK & 3 MK82	wp2
34	33.0	37.0	LOAD TER RACK & 3 MK82	wp3
35	37.0	41.0	UNLOAD MISSILE LAUNCHER	wp1
36	37.0	41.0	UNLOAD MISSILE LAUNCHER	wp2
37	37.0	41.0	UNLOAD MISSILE LAUNCHER	wp3
38	41.0	45.0	LOAD TER RACK & 3 MK82	wp2
39	41.0	45.0	LOAD TER RACK & 3 MK82	wp3

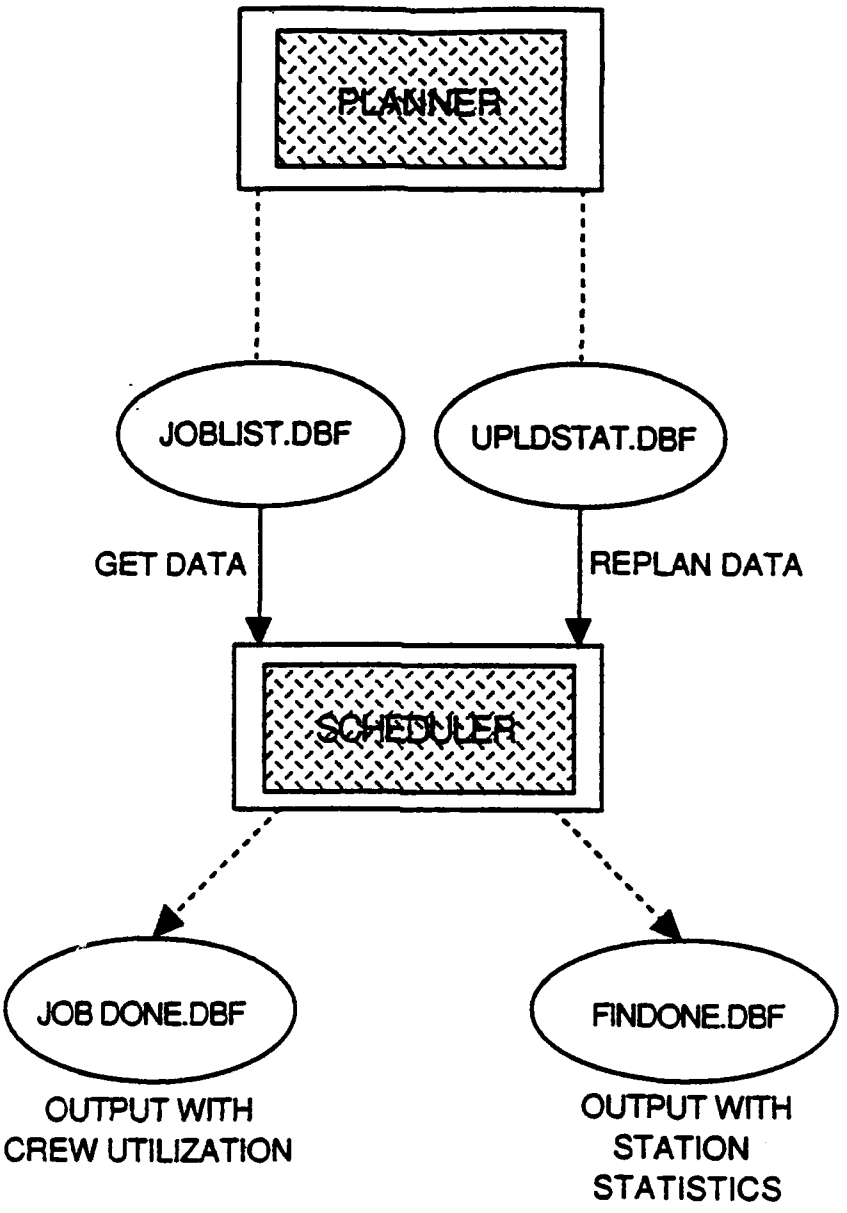

FIGURE 2: OUTPUT (INFORMATION) FLOW IN TOP

40	45.0	49.0	UNLOAD MISSILE LAUNCHER	wp1
41	45.0	49.0	UNLOAD MISSILE LAUNCHER	wp2
42	45.0	49.0	UNLOAD MISSILE LAUNCHER	wp3

Record#	STATION	SUBTASK
1	0	---
2	0	---
3	0	---
4	0	---
5	9	PRE-LOADING
6	9	PRE-LOADING
7	0	---
8	0	---
9	1	LOADING
10	1	LOADING
11	6	---
12	6	---
13	5	---
14	5	---
15	4	---
16	4	---
17	1	LOADING
18	1	LOADING
19	5	---
20	5	---
21	1	POST-LOADING
22	1	POST-LOADING
23	9	LOADING
24	9	LOADING
25	9	POST-LOADING
26	9	POST-LOADING
27	8	---
28	8	---
29	8	---
30	7	---
31	7	---
32	7	---
33	7	---
34	7	---
35	3	---
36	3	---
37	3	---
38	3	---
39	3	---
40	2	---
41	2	---
42	2	---

A request for Findjob.dbf print gives an output that is easy to read and interpret. This is shown in Appendix C.

3.2 Jobdone.dbf

The contents of this file are the profiles of the dynamic job nodes for each station. A typical content is as follows:

Record#	Name	JOB_NAME	STATION	PERSONNEL1	PERSON		ID	STARTTI ENDTIME
1	newjob1	LOAD CHAFF/FLARE	0	ch1	ch2	-	0	3.00
2	newjob2	GUM AMMO LOADING	0	wp3	temp	-	0	2.00
3	newjob3	REFUELING	0	rb	temp	-	0	3.00
4	newjob4	LOAD AIM-9L MISSILE	9	wp1	wp2	-	0	5.00
5	newjob5	SAFETY CHECK	0	ch1	ch2	-	3	8.00
6	newjob6	LOAD AIM-9L MISSILE	1	wp3	rb	-	5	10.00
7	newjob7	LOAD TER RACK & 3 MK82	6	wp1	wp2	-	5	9.00
8	newjob8	UNLOAD CENTERLINE PYLON	5	ch1	ch2	-	8	11.00
9	newjob9	LOAD TER RACK & 3 MK82	4	wp1	wp2	-	9	13.00
10	newjob10	LOAD AIM-9L MISSILE	1	wp3	rb	-	10	15.00
11	newjob11	LOAD 300 & REFUEL	5	ch1	ch2	-	11	16.00
12	newjob12	LOAD AIM-9L MISSILE	1	wp2	wp3	-	15	20.00
13	newjob13	LOAD AIM-9L MISSILE	9	wp1	rb	-	15	20.00
14	newjob14	LOAD AIM-9L MISSILE	9	wp2	wp3	-	20	25.00
15	newjob15	UNLOAD MISSILE LAUNCHER	8	wp1	wp2	-	25	29.00
16	newjob16	UNLOAD MISSILE LAUNCHER	7	wp1	wp2	-	29	33.00
17	newjob17	LOAD TER RACK & 3 MK82	7	wp2	wp3	-	33	37.00
18	newjob18	UNLOAD MISSILE LAUNCHER	3	wp1	wp2	-	37	41.00
19	newjob19	LOAD TER RACK & 3 MK82	3	wp2	wp3	-	41	45.00
20	newjob20	UNLOAD MISSILE LAUNCHER	2	wp1	wp2	-	45	49.00

3.3 Upldstat.dbf

The "update statistics" database contains flaggers to stations. Each flag (true or false) identifies which station needs replanning. If the flag value is true, an automatic data updating is done during scheduling. An example file content during planning and scheduling profiles is shown below:

Record#	ID	STATION
1	1	.F.
2	2	.F.

3	3	.F.
4	4	.T.
5	5	.F.
6	6	.T.
7	7	.F.
8	8	.F.
9	9	.F.

3.4 Joblist.dbf

This database contains the result of planning and constitutes the initial input to the scheduler. The file contains the job identification number (ID), the jobname, the station at which the job is to be performed, the expected time to perform a task under (a) human (TIME1) or (b) robot (TIME2). The starttime and endtime fields are slots to be completed after scheduling. The data below show an example Joblist.dbf:

Record#	ID	JOB_NAME	STATION	TIME1	TIME2	STARTTIME	ENDTIME
1	1	LOAD AIM-9L MISSILE	1	5.00	4.00	0.00	0.00
2	2	UNLOAD MISSILE LAUNCHER	2	4.00	3.00	0.00	0.00
3	3	UNLOAD MISSILE LAUNCHER	3	4.00	3.00	0.00	0.00
4	4	LOAD TER RACK & 3 MK82	3	4.00	4.00	0.00	0.00
5	5	LOAD TER RACK & 3 MK82	4	4.00	4.00	0.00	0.00
6	6	UNLOAD CENTERLINE PYLON & ECM	4	4.00	4.00	0.00	0.00
7	7	LOAD 300 & REFUEL	5	5.00	4.00	0.00	0.00
8	8	LOAD TER RACK & 3 MK82	6	4.00	4.00	0.00	0.00
9	9	UNLOAD MISSILE LAUNCHER	7	4.00	3.00	0.00	0.00
10	10	LOAD TER RACK & 3 MK82	7	4.00	4.00	0.00	0.00
11	11	UNLOAD MISSILE LAUNCHER	8	4.00	3.00	0.00	0.00
12	12	LOAD AIM-9L MISSILE	9	5.00	4.00	0.00	0.00
13	13	REFUELING	0	3.00	2.00	0.00	0.00
14	14	GUN AMMO LOADING	0	2.00	2.00	0.00	0.00
15	15	LOAD CHAFF/FLARE	0	3.00	3.00	0.00	0.00

REFERENCE

[1] Nii, H.P. (1986), "Blackboard Systems," AI Magazine, pp. 7.2-7.3.

APPENDIX A

STATEMENT OF WORK FOR TOP PLANNER AND SCHEDULER

(Knowledge creation and program validation about ATF are based on this task statement.)

DEPARTMENT OF THE AIR FORCE
WRIGHT RESEARCH AND DEVELOPMENT CENTER (AFSC)
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433-6553

REPLY TO ATTN OF: FIVMB/Lt Waltz 27 Aug 90

SUBJECT: Scope of Contract #24020154

TO: North Carolina A&T State University
1000 E. Market
406 McNair Hall
Greensboro NC 27411

1. After your visit to Wright-Patterson AFB on 3-4 Aug 90 to view an Integrated Combat Turnaround (ICT) and job control functions, further review was done on the work to be accomplished under this contract. The focus should be upon aircraft turnaround functions and what impact these tasks have on scheduling the work to get these jobs done. In order to simplify this task and provide a model that can be built upon, we recommend that you focus on one aircraft and the functions involved for a complete ICT. For this contract, we have selected the F-16A as the aircraft. We have also limited the possible configurations and the type of munitions the aircraft will simulate.

2. The following is a list of suspension equipment/munitions that the expert system will have to maintain in the database to load/unload and install/remove on the F-16. The database should allow easy addition or removal of new or old items and allow the times established for each step to be updated.

a. Wing Weapons Pylons w/MAU-12A/B bomb rack
b. Underwing Pylon Adapters
c. Missile Launchers
d. Centerline Pylons w/MAU-12A/B bomb rack
e. Wing Fuel Tanks (370)
f. Centerline Fuel Tank (300)
g. Ter-9A Rack loaded on wing weapons pylons
h. ECM Pods loaded on centerline pylon
i. AIM-9L Missiles w/arming handles
j. MK82/BSU-49 500-lb Bombs w/M904 nose fuze and FMU-54A/B tail fuze in the high drag configuration loaded on the TER only
k. MK84/BSU-50 2000-lb Bombs w/M904 nose fuze and FMU-54A/B tail fuze in the low drag configuration loaded on the MAU-12 bomb rack
l. LAU-88 Preloaded w/3 AGM-65A, B missiles
m. Chaff/Flare Modules (1 chaff on right and 1 flare on left)
n. 20mm Ammo using an ALS

3. A list of possible configurations is as follows:

Config Code*	9	8	7	6	5	4	3	2	1
AA1	M	M	M	-	ECM	-	M	M	M
AA2	M	M	M	370	300	370	M	M	M
AA3	M	M	M	-	-	-	M	M	M
AG1	M	-	A	A	300	A	A	-	M
AG2	M	-	A	370	ECM	370	A	-	M
AG3	-	-	B	B	ECM	B	B	-	-
AG4	M	-	C	-	300	A	A	-	M
AG5	M	-	C	370	300	370	C	-	M
AG6	M	M	B	B	300	A	A	M	M

A - 3 MK82'S MOUNTED ON A TER
B - MK84
C - 3 AGM-65'S MOUNTED ON A LAU-88 LAUNCHER
M - AIM-9L MISSILE MOUNTED ON MISSILE LAUNCHER
370 - FUEL TANK MOUNTED ON STATIONS 4 & 6
300 - FUEL TANK MOUNTED ON STATION 5
* ALL CONFIGURATIONS WILL CARRY CHAFF/FLARE MODULES AND THE 20MM GUN

4. The program should know the existing configuration of the aircraft before the ICT and then reconfigure, load and service the aircraft based on times established in the database. A printout of each step, who performed it, and the time required to do the step will be necessary for a checkout of the system. The individuals available on an ICT are the aircraft crew chief, assistant aircraft crew chief, weapons load crew chief and 2 additional weapons personnel. Each operation involving a weapon or munition must be accomplished by the weapons personnel only. Fuel tanks and ECM pods can be installed or removed by the aircraft crew chief and his/her assistant. The Battelle Report will be used to establish baseline times for the individual steps in each of the operations involved. In all the loading operations, assume that all munitions were expended, gun was fired, and chaff/flares were dispensed and need to be reloaded.

The aircraft will also require a full load of fuel for each ICT. If times for the individual steps are not in the Battelle report and procedures are not available in the T.O's provided, contact Lt Waltz at 513-257-2129 and he will get the necessary information for you.

David J. Perez, Tech Mgt
Special Projects Group
Aircraft Launch and Recovery Branch

6 Atch
1. T.O. 1F-16A-33-1-4
2. T.O. 1F-16A-33-1-2 Section II
3. T.O. 1F-16A-33-1-2 Section III
4. T.O. 1F-16A-33-1-2 Section X
5. T.O. 1F-16A-33-1-2 Section XVIII
6. T.O. 1F-16A-33-1-2 Section XXII

APPENDIX B

PLANNER CONTROL PROGRAM

```
* IMMMMMMMMMMMMMMMKMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM;
* : Program         : TUR.PRG                                                  :
* : System          : ARTFUL.LIB for Clipper Summer 87                         :
* : Functions       : ARTFULMENU(), UTIL_MENU(), VIEWFILE()                    :
* : Purpose         : Demonstrate Artful.Lib                                   :
* : Parameter       :                                                          :
* :     monochrome: If anything is passed, forces monochrome even if a        :
* :                 : colour adapter is present.                               :
* : Author          : William P. Byrd, Jr.                                     :
*                                                                              :
* HMMMMMMMMMMMMMMMJMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM<

PARAMETER monochrome
monochrome = ( TYPE( "monochrome" ) != "U" )

SYSCOLOR( 1 )
SET SOFTSEEK OFF
SET SCOREBOARD OFF
SET DELETED ON

SETUP( 39 )

exe_name  = "(T)ask (O)riented (P)lanner     Ver. 1.0"          && sign on
exe_desc  = "Aircraft Configuration Planning"
logo_line = "N.C. A&T State University  (C) W. P. Byrd, Jr. 1991"
SIGN_ON( exe_name, exe_desc, logo_line )

dict_file = "TUR_DICT"                             && dictionary filename
menu_size = 6

DECLARE cues[ menu_size ], msgs[ menu_size ], udfs[ menu_size ]

cues[ 1 ] = " Aircraft "
cues[ 2 ] = " Config "                          && program's light-bar menu
cues[ 3 ] = " T. A. F. "
cues[ 4 ] = " Function Tasks "
cues[ 5 ] = " Calculate "
cues[ 6 ] = " Utilities "


msgs[ 1 ] = "    Specific Aircraft information         "
msgs[ 2 ] = "    All possible Configurations for planning "
msgs[ 3 ] = "    Turnaround aircraft functions that make up configurations "
msgs[ 4 ] = "    Tasks that make up functions "
msgs[ 5 ] = "    Update totals after adding or changing function times"
msgs[ 6 ] = "    Program maintenance and configuration"

udfs[ 1 ] = "THE_USUAL('AIRCRAFT')"
udfs[ 2 ] = "THE_USUAL('CONFIG')"
udfs[ 3 ] = "THE_USUAL('FUNCTION')"
udfs[ 4 ] = "THE_USUAL('FUNCTASK')"
udfs[ 5 ] = "func_calc()"
udfs[ 6 ] = "UTIL_MENU()"

IF !CHK_DICT( dict_file )                          && Open the dictionary
    SET CURSOR ON
    QUIT
ENDIF

DESKTOP()                                          && startup screen
```

```
help_code = "INTRO"                                && Intro help screen
choice = 1
DO WHILE .T.                                       && Here comes the program...
    help_code = "MAINMENU"
    DO_IT( choice, cues, msgs, udfs )
    IF VERIFY( "Leave this program and return to DOS" )
        EXIT
    ENDIF
ENDDO                                              && ...There goes the program

SIGN_OFF( exe_name, exe_desc, logo_line )


* MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM *
FUNCTION UTIL_MENU                                 && Utilities menu
* MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM *
PRIVATE util_menu[ 6 ], udf_ra[ 6 ]

util_menu[ 1 ] = "Application Dictionary "
util_menu[ 2 ] = "Help index             "
util_menu[ 3 ] = "Pack all files         "
util_menu[ 4 ] = "Query maintenance      "
util_menu[ 5 ] = "System Configuration   "
util_menu[ 6 ] = "View a text file "

udf_ra[ 1 ]    = "DCT_MAINT(dict_file)"
udf_ra[ 2 ]    = "HELP_NTX()"
udf_ra[ 3 ]    = "PACKDICT(dict_file)"
udf_ra[ 4 ]    = "QUERIES()"
udf_ra[ 5 ]    = "CONFIGURE()"
udf_ra[ 6 ]    = "VIEWFILE()"

PULL_OPEN( util_menu, 3, 52, 1, .T., udf_ra )
RETURN .T.


* MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM *
EXTERNAL DBEDIT
EXTERNAL XBROWSER, XB_UDF, THE_USUAL, ;            && Required by all programs
         SET_TABLE, DO_SWAP, PACKDICT, ;           && calling THE_USUAL().
         QUERIES
EXTERNAL CONFIGURE                                 && You'll usually want this.
EXTERNAL DCT_MAINT                                 && Probably you'll take this out
                                                   && just before you ship.
EXTERNAL RPT_MENU, RPT_EXEC                        && Required for all reports.
EXTERNAL RPT_RRUN                                  && RRUNTIME caller.
EXTERNAL AUTO_INIT                                 && RELATIONS and TIPS use it here
EXTERNAL HELP_NTX
EXTERNAL VIEWFILE, READPREV, DUST_1
* MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM *

function func_calc
* calculate total times for all tasks
* hazardous and non hazardous

select functask
goto top
do while .not. eof()
   replace haz_time with tj*sj*dj*fj
```

```
   replace nhaz_time with  tj*sj*fj
   skip
enddo

* sum times for A = load tur
go top
sum haz_time for funccode = "A" to htot
sum nhaz_time for funccode = "A" to nhtot

select function
go top
seek "A"
replace time2 with htot
replace time1 with nhtot

* sum times for B = bomb load
select functask
sum haz_time for funccode = "B" to htot
sum nhaz_time for funccode = "B" to nhtot

select function
go top
seek "B"
replace time2 with htot
replace time1 with nhtot

* sum times for M = Aim-9 missle load
select functask
sum haz_time for funccode = "M" to htot
sum nhaz_time for funccode = "M" to nhtot

select function
go top
seek "M"
replace time2 with htot
replace time1 with nhtot

* sum times for 300 = Centerline fuel tank
select functask
sum haz_time for funccode = "300" to htot
sum nhaz_time for funccode = "300" to nhtot

select function
go top
seek "300"
replace time2 with htot
replace time1 with nhtot

* sum times for 370 = Wing fuel tank
select functask
sum haz_time for funccode = "370" to htot
sum nhaz_time for funccode = "370" to nhtot

select function
go top
seek "370"
replace time2 with htot
replace time1 with nhtot

* sum times for ECM = Electronic counter measure
```

```
select functask
sum haz_time for funccode = "ECM" to htot
sum nhaz_time for funccode = "ECM" to nhtot

select function
go top
seek "ECM"
replace time2 with htot
replace time1 with nhtot

* sum times for C = Preloaded lau-88
select functask
sum haz_time for funccode = "C" to htot
sum nhaz_time for funccode = "C" to nhtot

select function
go top
seek "C"
replace time2 with htot
replace time1 with nhtot

* sum times for CUR = cursory inspection
select functask
sum haz_time for funccode = "CUR" to htot
sum nhaz_time for funccode = "CUR" to nhtot

select function
go top
seek "CUR"
replace time2 with htot
replace time1 with nhtot
pop_msg("Finished calculating.. Thank you")
return 1


function config
config_code = space(3)
prompt="Enter configuration code for Scheduling"

ask_for(prompt,@config_code,"!!!")

select config
go top
seek config_code

select upldstat
go top
if empty(config->station1)
   store 1 to id
   store .f. to station
   skip
else
   store 1 to id
   store .t. to station
   skip
endif
if empty(config->station2)
   store 2 to id
   store .f. to station
   skip
```

```
else
   store 2 to id
   store .t. to station
   skip
endif
if empty(config->station3)
   store 3 to id
   store .f. to station
   skip
else
   store 3 to id
   store .t. to station
   skip
endif
if empty(config->station4)
   store 4 to id
   store .f. to station
   skip
else
   store 4 to id
   store .t. to station
   skip
endif
if empty(config->station5)
   store 5 to id
   store .f. to station
   skip
else
   store 5 to id
   store .t. to station
   skip
endif
if empty(config->station6)
   store 6 to id
   store .f. to station
   skip
else
   store 6 to id
   store .t. to station
   skip
endif
if empty(config->station7)
   store 7 to id
   store .f. to station
   skip
else
   store 7 to id
   store .t. to station
   skip
endif
if empty(config->station8)
   store 8 to id
   store .f. to station
   skip
else
   store 8 to id
   store .t. to station
   skip
endif
if empty(config->station9)
```

```
      store 9 to id
      store .f. to station
      skip
   else
      store 9 to id
      store .t. to station
      skip
   endif

   return 1
```

APPENDIX C

JOB SCHEDULE PROFILES
(A Print Request of Findjob.dbf)

Scheduling List for Each Job

Job Names	Station	Start	End	Personnel		
LOAD CHAFF/FLARE	0	0.00	3.00	ch1	ch2	
GUM AMMO LOADING	0	0.00	2.00	wp3		
REFUELING	0	0.00	3.00	rb		
LOAD AIM-9L MISSILE PRE-LOADING	9	0.00	5.00	wp1	wp2	
SAFETY CHECK	0	3.00	8.00	ch1	ch2	
LOAD AIM-9L MISSILE PRE-LOADING	1	5.00	10.00	wp3	rb	
LOAD TER RACK & 3 MK82	6	5.00	9.00	wp1	wp2	
UNLOAD CENTERLINE PYLON & ECM	5	8.00	11.00	ch1	ch2	
LOAD TER RACK & 3 MK82	4	9.00	13.00	wp1	wp2	
LOAD AIM-9L MISSILE LOADING	1	10.00	15.00	wp3	rb	
LOAD 300 & REFUEL	5	11.00	16.00	ch1	ch2	
LOAD AIM-9L MISSILE POST-LOADING	1	15.00	20.00	wp2	wp3	
LOAD AIM-9L MISSILE LOADING	9	15.00	20.00	wp1	rb	
LOAD AIM-9L MISSILE POST-LOADING	9	20.00	25.00	wp2	wp3	
UNLOAD MISSILE LAUNCHER	8	25.00	29.00	wp1	wp2	wp3
UNLOAD MISSILE LAUNCHER	7	29.00	33.00	wp1	wp2	wp3
LOAD TER RACK & 3 MK82	7	33.00	37.00	wp2	wp3	
UNLOAD MISSILE LAUNCHER	3	37.00	41.00	wp1	wp2	wp3
LOAD TER RACK & 3 MK82	3	41.00	45.00	wp2	wp3	
UNLOAD MISSILE LAUNCHER	2	45.00	49.00	wp1	wp2	wp3

Scheduling List for Each Personnel

Job Names	Station	Start	End	Personnel
LOAD AIM-9L MISSILE PRE-LOADING	9	0.00	5.00	Personnel_1
LOAD TER RACK & 3 MK82	6	5.00	9.00	Personnel_1
LOAD TER RACK & 3 MK82	4	9.00	13.00	Personnel_1
LOAD AIM-9L MISSILE LOADING	9	15.00	20.00	Personnel_1
UNLOAD MISSILE LAUNCHER	8	25.00	29.00	Personnel_1
UNLOAD MISSILE LAUNCHER	7	29.00	33.00	Personnel_1
UNLOAD MISSILE LAUNCHER	3	37.00	41.00	Personnel_1
UNLOAD MISSILE LAUNCHER	2	45.00	49.00	Personnel_1

Scheduling List for Each Personnel

Job Names	Station	Start	End	Personnel
LOAD AIM-9L MISSILE PRE-LOADING	9	0.00	5.00	Personnel_2
LOAD TER RACK & 3 MK82	6	5.00	9.00	Personnel_2
LOAD TER RACK & 3 MK82	4	9.00	13.00	Personnel_2
LOAD AIM-9L MISSILE POST-LOADING	1	15.00	20.00	Personnel_2
LOAD AIM-9L MISSILE POST-LOADING	9	20.00	25.00	Personnel_2
UNLOAD MISSILE LAUNCHER	8	25.00	29.00	Personnel_2
UNLOAD MISSILE LAUNCHER	7	29.00	33.00	Personnel_2
LOAD TER RACK & 3 MK82	7	33.00	37.00	Personnel_2
UNLOAD MISSILE LAUNCHER	3	37.00	41.00	Personnel_2
LOAD TER RACK & 3 MK82	3	41.00	45.00	Personnel_2
UNLOAD MISSILE LAUNCHER	2	45.00	49.00	Personnel_2

Scheduling List for Each Personnel

Job Names	Station	Start	End	Personnel
GUM AMMO LOADING	0	0.00	2.00	Personnel_3
LOAD AIM-9L MISSILE LOADING	1	5.00	10.00	Personnel_3
LOAD AIM-9L MISSILE LOADING	1	10.00	15.00	Personnel_3
LOAD AIM-9L MISSILE POST-LOADING	1	15.00	20.00	Personnel_3
LOAD AIM-9L MISSILE POST-LOADING	9	20.00	25.00	Personnel_3
UNLOAD MISSILE LAUNCHER	8	25.00	29.00	Personnel_3
UNLOAD MISSILE LAUNCHER	7	29.00	33.00	Personnel_3
LOAD TER RACK & 3 MK82	7	33.00	37.00	Personnel_3
UNLOAD MISSILE LAUNCHER	3	37.00	41.00	Personnel_3
LOAD TER RACK & 3 MK82	3	41.00	45.00	Personnel_3
UNLOAD MISSILE LAUNCHER	2	45.00	49.00	Personnel_3

Scheduling List for Each Personnel

Job Names	Station	Start	End	Personnel
LOAD CHAFF/FLARE	0	0.00	3.00	Chief_1
SAFETY CHECK	0	3.00	8.00	Chief_1
UNLOAD CENTERLINE PYLON & ECM	5	8.00	11.00	Chief_1
LOAD 300 & REFUEL	5	11.00	16.00	Chief_1

Scheduling List for Each Personnel

Job Names	Station	Start	End	Personnel
LOAD CHAFF/FLARE	0	0.00	3.00	Chief_2
SAFETY CHECK	0	3.00	8.00	Chief_2
UNLOAD CENTERLINE PYLON & ECM	5	8.00	11.00	Chief_2
LOAD 300 & REFUEL	5	11.00	16.00	Chief_2

Scheduling List for Each Personnel

Job Names	Station	Start	End	Personnel
REFUELING	0	0.00	3.00	Robert
LOAD AIM-9L MISSILE LOADING	1	5.00	10.00	Robert
LOAD AIM-9L MISSILE LOADING	1	10.00	15.00	Robert
LOAD AIM-9L MISSILE LOADING	9	15.00	20.00	Robert

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